S P E C I F I C A T I O N

Docket No. 0438CG-54

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that we, Fred R. Huege, a resident of the state of Texas, and Starr Curtis, a resident of the state of Arizona, both citizens of the United States of America, have invented new and useful improvements in a

COMPOSITION FOR ASPHALT ROOFING MATERIALS

of which the following is a specification:

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to asphaltic or bituminous roofing materials and methods, and more particularly to the manufacture of such roofing materials to which hydrated lime ($Ca(OH)_2$, abbreviated as "HL") is added to improve the strength, durability and antioxidant qualities of the roofing material. The roofing materials may be shingles, rolls, or other materials to be placed on roofs.

2. Description of the Prior Art:

Asphalt roofing shingles are manufactured by taking a continuous base sheet of organic felt or fibreglass (generally, a web or form), saturating it in a base asphalt, covering it with a coating asphalt, and then embedding granules on the top side of the coated sheet. The granules protect the asphalt from breaking down through oxidization by ultra violet rays. Fillers such as $CaCO_3$ and/or fly ash may also be used in the asphalt composition. Finally, synthetic polymeric materials may also be added to the asphalt. The finished sheet is cut into lanes and to a desired length of shingles.

More specifically, in the manufacture of roofing shingles or rolls, a heated asphaltic/filler blend is applied to a substrate web or substrate form, such as a glass fiber mat or a felt. The mat or felt is pre-shaped

in the form that is desired for roofing purposes. After the form or web is impregnated with the asphaltic mix, a granular treatment may be applied to the hot asphalt surface and rolled or pressed into place. The coated web composition is then cooled so that it may be cut and bundled as shingles, or formed into rolls.

The use of tar with HL to cover roofs is old in the art, as disclosed in U.S. Pat. No. 61,787 (disclosing first coating wooden shingles with HL, allowing it to dry, then coating the shingles with the tar, followed by sand). Asphaltic or bituminous materials as used in the roofing industry for pre-fabricated shingles or asphalt rolls are well known in the art, with the examples being described in U.S. Pat. No. 4,405,680 (disclosing a specific type of asphalt with glass filaments and method of manufacture), and 4,559,267 (disclosing a sealant bound to asphalt sheets). Prior to application to the substrate or web form, the asphalt is typically heated in an asphalt heater to a temperature of up to 500°F. The heated asphalt is then blended with a filler that may or may not be chemically inert, the filler also having been preheated to a temperature necessary so as not to chill the mix and to facilitate blending with the asphalt.

The choice filler has traditionally been based on considerations of availability, compatibility and cost. An inert filler material which has been preferred and used by many roofing plants is powder limestone ($CaCO_3$) or dolomite ($CaCO_3 \cdot MgCO_3$), usually at a rate of about 40% to 70% by weight of the mix. Other materials may also be

blended with the asphalt, such as block and anti-block polymers and thinners, as well known in the art.

Powder limestone often has been a filler of choice as it is widely available at a relatively low cost, and is compatible with the asphalt mix. However, it is a poor conductor of heat when compared to fly ash. It is relatively slow to heat, and therefore, in the mix, tends to insulate the asphalt and retards the cooling of the composite web or form. Further, $CaCO_3$ is an active base material, and it therefore tends to be acted upon by the weak acid and the precipitation (acid rain) and is believed to contribute to a shortened life of the roofing material. More importantly, limestone fillers have been documented as the cause of algae growth and discoloration in asphaltic shingled roofs. This is somewhat undesirable since it decreases the life of the shingles, and also lowers the aesthetic quality of the shingles. In this regard, $MgCO_3$ may be a better filler for asphalt.

In any case, it is desirable to have present in the asphalt shingle a substance that can counter these and other detrimental effects of filler agents or the asphalt itself. At the same time, it is desirable to improve the durability of roofing material and increase its tear strength. While HL has been recently disclosed in use as a filler in asphalt for paving roads (U.S. Ser. No. 09/110,410, filed on July 6, 1998), HL has not been used in asphalt shingles or other roofing materials. Thus, the present invention discloses a roofing composition that is an improvement on the prior art that incorporates the advantages of HL.

SUMMARY OF THE INVENTION

One object of the present invention is to provide an improved roofing composition of shingles or asphalt roll having a low cost additive that imparts improved tear strength to the shingles, and is cost effective to use.

Another object of the present invention is to provide an asphalt shingle of improved strength that can be made with various types of asphalt.

These and other objects are achieved in an asphalt roofing composition in the form of a roll or a shingle-like structure in which a hot mixture of an asphaltic base and filler is applied to a substrate form, wherein the composition also comprises an amount of hydrated lime (HL, such as any alkaline earth metal hydroxide) in order to impart strength and durability to the composition. The composition contains HL between about 1-10%, and preferably between about 3-5%, of the asphalt by weight. The filler can be fly ash, $CaCO_3$, $MgCO_2 \cdot CaCO_3$, $MgCO_3$, or other suitable materials known in the art. In a typical embodiment of the invention, the HL is added directly to the asphaltic base of the composition either with the filler, or with filler added after mixing the asphalt and HL, or mixing the asphalt with the filler and then adding the HL.

Additional objects, features and advantages will be apparent in the written description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph of a SHRP parameter as a measure of permanent deformation potential for different asphalt binders with the addition of 20% HL by weight of asphalt binder;

Figure 2 is a graph of the change in viscosity of one HMA composition as a function of reaction time and blending time;

Figure 3 is a graph similar to **Figure 2**, but showing the results obtained with a second HMA composition;

Figure 4 is a graph of fracture toughness for one HMA composition with the addition of 20% by weight of HL;

Figure 5 is a graph similar to **Figure 4**, but with a second HMA composition;

Figure 6 is a graph of accumulated shear deformation for HMA mixes using two different bituminous binders;

Figure 7 is a graph of controlled-stain fatigue life comparing HMA's with and without the addition of HL;

Figure 8 is a top view of a typical asphalt shingle;

Figure 9 is a top view of a roof having asphalt roll material placed below a series of asphalt shingles; and

Figure 10 is a graph of the tear strength of the shingles of the invention when compared to traditional (control) shingles.

DETAILED DESCRIPTION OF THE INVENTION

The following abbreviations are used throughout the specification: SHRP is Strategic Highway Research Program; HL is hydrated lime ($Ca(OH)_2$, $Mg(OH)_2$ or $Ca(OH)_2 \cdot Mg(OH)_2$); HMA is hot mix asphalt; and IDT is Indirect Tensile. Other abbreviations are defined as they are used.

The present invention is directed to improvements in asphalt roofing materials and similar bituminous compositions in which a lime component, preferably HL, is added directly to the asphalt or asphalt in one embodiment, or first to the filler and then to the asphalt in another embodiment. In yet another embodiment, the HL is added to the mixture of filler and asphalt. Hereinafter, the terms "bitumen" and "asphalt" are used interchangeably. Further, the term HL is used to refer in general to any alkaline earth metal hydroxide such as $Mg(OH)_2$ and $Ca(OH)_2$, or mineral mixture thereof (generally, $Ca(OH)_2 \cdot Mg(OH)_2$). In the disclosure which follows, the term "quicklime" refers to alkaline earth metal oxides such as CaO, while the use of HL refers to alkaline earth metal hydroxides such as $Ca(OH)_2$.

In the production of HL, limestone or calcium carbonate is first heated to remove carbon dioxide. The remaining CaO is a very active chemical. To improve the handling characteristics of the quicklime, a controlled amount of water is added to form HL. Adding a HL component to the aggregate or filler (e.g., rock, sand, fly ash, limestone) in asphaltic compositions is done in

the present invention with the intention of improving the bond between the aggregate/filler, fiber glass matte or other substrate form, and asphalt, especially in the presence of water which has a stronger affinity for the aggregate than the asphalt does. This in turn improves the tear strength of the shingle-like structure or roofing material. Hydrated lime added to the aggregate is an effective antistripping agent and has been considered to have ancillary positive effects on the asphalt mixture.

The mechanism by which HL improves aggregate-asphalt adhesion and moisture sensitivity when the HL is added directly to aggregate is reasonably well understood although some arguments still exist as to the mechanisms responsible. It is theorized that the lime decreases the interfacial tension between the asphalt and water, thus resulting in good adhesion. It is also thought that the HL improves the stripping resistance by interacting with the carboxylic acids in the asphalt. This interaction forms insoluble products that are readily adsorbed onto the surface of the aggregate or filler, or in the specific case of roofing materials, the substrate form or web used to make the shingle-like structures or rolls. Some studies indicate that strong adsorption of calcium onto mineral aggregate surfaces may contribute to bonding of asphalt cements with the aggregate or filler.

The following data demonstrates that HL added directly to asphalt has a multi-functional effect. The effect which is achieved is more than simply that of an antistrip additive. Hydrated lime was added directly to

five different asphalts (denoted AAB, AD, AAF, AAG and AAM) which represent the range of asphalts that would reasonably be encountered in the United States and throughout most of the world, as discussed in Table 1. Each of the selected asphalts represents a wide variety of asphalt chemical and physical properties. The research in the asphalt study concentrated on using testing techniques that are now being accepted by the industry as part of the Strategic Highway Research Program's (SHRP) Superpave protocol. However, some non-traditional tests were also performed. The testing protocol is given below in Table 1. Although these data apply to asphalt compositions for road use, they also equally apply in general to the use of asphalt/HL compositions in any conditions where there is exposure to weather and physical stresses. These results, along with those discussed in **Figure 10** below, show that the asphaltic shingle composition of the present invention has improved characteristics relative to typical asphalt shingles, the HL having unexpected benefits.

Table 1. Tests performed upon various bituminous compositions.

Test	Parameters Measured	Purpose of Test
Series I - Investigation of low temperature performance IDT - Performed at three low temperatures for one hour to provide low temperature creep compliance on mixtures subject to aging (loose mix and compacted mix) according to Superpave protocol	Creep compliance versus time of loading - ultimate compliance, rate of change in compliance	Assess low temperature fracture properties (2 replicates for each mixture system - 18 samples)
IDT - Tensile strength at three low temperatures on mixtures subjected to aging as described above (AAMAS protocol)	Stress and strain at failure	Assess low temperature fracture properties (18 samples)
Series II - Investigation of intermediate temperature performance IDT - creep and tensile strength at intermediate temperature (20°C) to assess fracture properties (AAMAS protocol)	Creep compliance versus time of loading - ultimate compliance, rate of change in compliance	Assess intermediate temperature fracture fatigue properties (36 samples)
Series III - Investigation of moisture resistance Perform AASHTO T-283	Retained tensile strength	Assess effect of HL on moisture resistance (18 samples)
SERIES IV - Investigation of high temperature performance Compressive creep performed at 60°C one hour to assess permanent deformation potential (AAMAS protocol)	Creep compliance versus time of loading - ultimate compliance, rate of change in compliance	Assess effect of HL on high temperature rutting (6 samples)

Test	Parameters Measured	Purpose of Test
Repeated load (axial loading) permanent deformation testing at 60°C	Ultimate accumulated strain, rate of accumulated strain and slope of steady state region	Assess susceptibility of permanent deformation and the effect of HL (6 samples)
Repeated shear permanent deformation testing at 60°C	Same as above	Same as above (6 samples)

The following summary of the experimental work is divided into three sections: high temperature rheology, low temperature rheology and intermediate temperature rheology. At high temperatures, asphalt becomes soft and susceptible to shoving and rutting when used in roadways, and creeping or deformation when used as roofing materials. The tests performed evaluated the ability of the asphalt to withstand the stresses induced in high temperature environments. At low temperatures, asphalt becomes hard and susceptible to fracture. This is particularly true for asphalt mixtures that have become embrittled due to aging. The tests performed at low temperatures evaluate the ability of the asphalt to withstand load-induced and environmentally induced stresses at low temperatures. Load-induced fatigue cracking typically occurs at low and intermediate temperatures. The test performed at intermediate or average temperatures assess the ability of the asphalt to withstand fatigue at average or nominal temperatures. The tests were conducted by reacting the asphalts in mass with the HL in closed containers in accordance with the previously enunciated testing protocols.

Evaluation of the Effects of HL on High Temperature Rheology. Hydrated lime added directly to the asphalt in selected ranges from about 10% to about 20% by weight, based on the total weight of asphalt binder produces several high temperature rheology effects which can be summarized as follows:

Hydrated lime added to asphalts has a very positive filler effect. This effect substantially improves high temperature rheological parameters which relate to resistance to permanent deformation. **Figure 1** shows how 20% HL by weight asphalt binder dramatically changes the SHRP parameter $G^*/\sin\delta$ which is related to permanent deformation potential. A high $G^*/\sin\delta$ results in reduced permanent deformation potential. Somewhere between 10% and 20% HL by weight asphalt binder is required to provide the desired high temperature rheological changes. In the HL containing shingles, only about 1 to 10% HL by total weight of asphaltic/filler composition is required to effectuate an improvement in tear strength and antioxidant properties.

The high temperature rheology of HL-filled asphalts is dependent on the time and temperature of blending of HL with the asphalt. The process is asphalt specific. This finding demonstrates that the interaction between HL and asphalt is likely not simply physical but a chemical interaction may also exist.

Figures 2 and **3** illustrate the effect of reaction time at 149°C on HL in asphalt AAD to reaction time of longer than five minutes. However, asphalt AAM requires a reaction time of about 40 minutes to achieve viscosity equilibrium. This indicates a physio-chemical interaction unique to specific binders. Note that the untreated asphalts are unaffected by reaction time. Since the asphalts were reacted in mass in closed containers, oxidative aging should not be a factor. However, the HL, when added to the asphalt in roofing

materials, will decrease oxidative aging and thus improve the performance of the shingles or roll materials.

Evaluation of the Effects of HL on Low Temperature Rheology. The findings with regard to low temperature rheology are summarized as follows:

Hydrated lime increases the low temperature stiffness of asphalts indicating that they are more susceptible to low temperature fracture. However, HL added at rates of 12.5% by weight of asphalt and below has a small effect on low temperature stiffness and does not significantly affect the slope of the stiffness versus time of loading curve determined using the low temperature Bending Beam Rheometer test. SHRP research indicates that the slope is more important. Thus, adding 1-10% HL to the asphalt composition will also improve the properties of the roofing materials.

To evaluate whether the stiffness increase at low temperature due to HL addition is important, low temperature fracture tests were performed. Hydrated lime substantially improves low temperature fracture toughness. The improved fracture toughness and minimal effect on the slope of the stiffness versus time of loading curve indicates improved low temperature crack resistance despite the increased stiffness.

Figures 4 and **5** illustrate the effect of HL in improving fracture toughness.

The improved low temperature properties are due to a synergistic effect of reduction in the effect of oxidative aging (as all samples are aged to simulate pavement aging before testing) and crack pinning, a phenomenon of energy dissipation due to microcrack interception by the dispersion of HL particles in the asphalt.

Evaluation of Effects of HL on Intermediate Temperature Rheology. The filler effect of HL is obvious at all temperatures. However, at low temperatures the stiffening effect was proven to be more than compensated for by the improvement in fracture toughness. No generally recognized accepted binder tests are available by which to evaluate intermediate temperature fatigue susceptibility. Therefore, the following mixture tests used: direct tensile fatigue tests and microcrack healing tests. These tests provided favorable results which are discussed in the mixture section.

HL in Asphalt -- Effects on Mixture Properties. Hydrated lime was added to two asphalts with very different chemical and physical properties. These asphalts are designated AAD and AAM. Mixtures with Watsonville granite aggregate and 5.05% asphalt by total weight of the mixture were subject to two types of mixture tests: repeated shear permanent deformation testing and direct tensile fatigue testing. The repeated stress, permanent deformation testing was performed to assess rutting potential in the mixtures tested. The direct tensile fatigue testing was performed to assess the effect of lime on the potential of the mixture to develop fatigue

cracking. These are two of the dominant distress mechanisms in hot mix asphalt pavements and are responsible for the vast majority of pavement damage and deterioration.

Results of Permanent Deformation Testing. The repeated shear permanent deformation testing was performed at 40°C. The testing was performed using a testing protocol developed in the SHRP research program to simulate the stress state that an asphalt mixture is subjected to under a moving wheel load. During the testing sequence the mixture is subjected to a constant ratio of axial stress and repeated shearing stresses.

Tests were performed on HMA mixtures prepared with four different asphalt binders with and without HL as follows: AAD, AAD 12.5% HL, AAM and AAM with 12.5% HL. Three identical samples were prepared for each mixture and the mixtures were subjected to a 20,000 lbs. load application. The tests revealed that the addition of HL reduced the level of permanent deformation on average about 300% (**Figure 6**), based on values of ultimate permanent strain after 20,000 cycles. The data were considerably variable, however. Although the above tests were performed on mixtures of asphalt and granite aggregate, the same or similar results are expected with glass filaments and/or fly ash, or the substrate forms used to make the shingles or roofing rolls of the invention, as they have the common property of being siliceous and/or carbonaceous.

Results of Direct Tensile Fatigue Testing. The purpose of direct tensile fatigue testing was to assess the resistance of asphalt mixtures to load-induced (controlled-strain) fatigue testing at intermediate (or average annual) pavement and exterior temperatures that shingles will be exposed to. Identical mixtures of Watsonville granite and 5.0% asphalt (by total weight of the mixture) were prepared with asphalt binders with and without HL as follows: AAD, AAD with 12.0% HL, AAM and AAM with 12.5% HL. Analysis of the results of controlled-strain fatigue testing demonstrated two findings. First, at a given level of stiffness, the addition of HL improved fatigue life. Second, the recovery of dissipated energy (responsible for crack healing) after rest periods is enhanced by the addition of HL for mixtures subject to age hardening. For a given design stiffness and for a mixtures subject to age hardening, the addition of HL appears to enhance the resistance to fatigue cracking.

Figure 7 illustrates typical fatigue results where cycles to failure (Nf) are compared for untreated and HL treated mixtures at various mixture stiffness.

An invention has been shown with several advantages. HL is an effective multi-functional additive which is effective in improving the high temperature performance of hot mix asphalt.

Uniaxial tensile controlled strain fatigue tests, performed on mixtures with and without the addition of HL added directly to the binder, demonstrate that the lime

addition improves the fatigue life of the mixture (resistance to cracking) when mixtures are compared at a common level of stiffness.

Shingles, shingle-like structures which come in various forms, or asphalt rolls used for roofing typically are made from glass impregnated mats or substrate forms, the asphalt and fillers, etc. being bound and formed around the mat or form. The shingles can be as shown in **Figure 8**, wherein asphalt shingle 10 having an adhesive strip 12 is shown. A number of shingles 10 are placed upon a roof 16 as in **Figure 9**, wherein sheet material from a roll of asphalt material 14 is first placed on the roof underneath the layered shingles 10. The roll comprises a rolled sheet of asphaltic material, usually formed around a substrate web or form, the layer of material placed directly in contact with the wood roofing material prior to addition of the shingles as in **Figure 8**. Further, various polymers can be added to the asphalt along with the HL of the invention, such as disclosed in U.S. Pat. No. 4,405,680.

Typical fillers for the composition include limestone and/or dolomite dust and glass fibers of various sizes and lengths, sand, rock (of various mineral composition), and other substantially siliceous materials in ground and/or powdered form. The asphalt utilized in the asphalt composition of the present invention is typical of the industry. An asphalt of this type typically has a softening point of between, for example, 190°F and 240°F and a penetration at 77°F between, for example, 14 dmm and 25 dmm (dmm is tenths of a

millimeter). In saturating the substrate form, the asphalt is maintained in a molten state, preferably at a temperature any where between 350°F and 450°F. At this temperature and without any fillers or additives, the molten asphalt has a viscosity and Saybolt furol seconds of 100 and 300.

The physical properties of the asphalt, as recited herein, are for exemplary purposes only. Any asphalt which functions in the manner to be described herein may be utilized, and in fact, may be readily provided by those skilled in the art. In this regard, the saturating or coating temperature of the molten asphalt, or the operating temperature as it is commonly called, will depend in part on the particular asphalt used and in part on other ingredients in the overall composition. In any event, the temperature of the asphalt should be sufficiently high to readily saturate or coat the substrate form with the asphalt composition, yet it should not be maintained at a temperature higher than necessary. This is, of course, because a large amount of energy is required to maintain the composition in its molten state.

The asphalt composition of the present invention preferably includes between about 30% and 50% asphalt by weight of the total composition. When less than approximately 30% is provided, the asphalt does not satisfactorily fulfill its intended purpose, that is, it does not satisfactorily provide the ultimately produced shingle or roll with adequate physical characteristics. In addition, it tends to be too viscous at the preferred

saturating temperatures and thus increases creep. On the other hand, providing the composition with more than 50% asphalt is not necessary and, taking into account costs considerations, is not preferable. In this regard, to extend the asphalt, a suitable conventional filler, such as for example, limestone and other mineral filler is added thereto.

The mineral filler is dispersed throughout the asphalt by conventional means. For example, mechanical agitation, when the asphalt is in its molten state, preferably at this saturating temperature. Between approximately 45% and 55% mineral filler, by way of the total composition, is preferably utilized. The exact percentage of mineral filler provided will be dictated by the amount of asphalt and the amount of glass in the form of glass fiber bundles which are utilized in the composition, especially when these are the only ingredients comprising the composition. Of course, the filler must not be of a type or an amount which will prevent saturation of the base sheet at any reasonable saturating temperature.

There are several principle methods of mixing the composition of the invention. The first is to add the HL to the molten asphalt. The second is to add the HL to the filler first, mixing or agitating it thoroughly first, with or without excess water, then adding the molten asphalt. A third method is to first mix the asphalt and filler, then add the HL to the mixture. In either case, the HL is added to between 1% and 10% of the added asphalt. Preferably, the HL is added to an amount

between 3% and 5% of the weight of the asphalt. Hydrated lime is added as a powder. The asphalt/HL and/or filler/HL mixtures are typically agitated to achieve an uniform distribution of the lime. This can be done with a pug mill, however, in some cases vigorous mixing is not necessary.

In one embodiment, the HL is added directly to the filler first as a dry powder, both ground and mixed to form a homogeneous mixture. The HL can be added prior to or after grinding the filler material. In yet another embodiment, CaO (or CaO·MgO) is added to wet or damp rock, thus being hydrated in a reaction between the CaO and H_2O to form $Ca(OH)_2$ (or $Ca(OH)_2 \cdot Mg(OH)_2$). The reaction mixture is then ground to the desired particle size. In yet another embodiment, CaO (or CaO·MgO) or HL slurry is added to the rock prior to grinding to the desired particle size.

The HL can also be mixed with the asphalt as the asphalt is heated to make the mixing easier. The temperature is dependent upon the type of asphalt, as discussed above, and its viscosity.

As stated above, in accordance with the present invention, a small percentage of glass in the form of glass fiber bundles is added to the asphalt filler mixture. These glass fiber bundles are dispersed throughout this mixture and could be dispersed throughout the asphalt prior to the addition of the filler but in any case, are added while the asphalt is in its molten state, preferably at its saturating temperature. In this

regard, the glass may be dispersed in the asphalt by, for example, mechanical agitation.

As stated previously, the asphalt-filler mixture, when maintained at the saturating temperature between 350°F and 450°F, will have a sufficiently low viscosity so as to permit easy saturation of the base sheet. While the addition of the glass fiber bundles to this mixture will increase the viscosity slightly, the amount and type of bundle selected must be such that the overall composition at the saturating temperature has a sufficiently viscosity level to permit easy saturation of the base sheet.

The exact type of glass fiber mat which could be used may vary and could also be readily determined by those skilled in the art in view of the teaching of the present invention. However, those which have been found to be acceptable are between approximately ⅛ and ½ in length, including between 100 and 800 per bundle and having a filament diameter of, for example, 13 to 18 micrometers. The binder utilized in holder the micro filaments together must be, of course, one of which will continue to hold the bundles together, to at least to a substantial degree, and the saturating temperature of the asphalt, even though the asphalt is mildly agitated to disperse the glass bundles. It must also be one which by melting, dissolving or any other way, allows the fiber bundles to defilamentize to a large extent at substantially higher asphalt temperatures, for example, at temperatures in excess of 700°F. Limestone ($CaCO_3$),

sand, fly ash, and other siliceous materials are typical binders used each alone or in some combination.

In one embodiment of the present invention, the shingles are manufactured by first providing a fiberglass mat of a preformed shape and size. Hot asphalt having the filler and HL is then applied to the top of the mat to the desired thickness. The asphalt is then allowed to dry. Next, the uncoated side of the mat is exposed, and hot asphalt is then applied to the uncoated surface to the desired thickness. This is then allowed to dry. In a finished product, sand or other decorative material may be added to the surface prior to drying to adhere the sand or other material the surface of the shingle.

The shingles of the present invention have the unexpected advantage of having a greater tear strength than traditional asphalt shingles not using HL. The data in **Figure 10** highlight this aspect of the present invention, wherein control samples (filled circles) of shingles that do not have HL were compared with the HL containing shingles (closed squares) of the present invention. Shingles of various thickness (in fractions of an inch) were compared and the tear strength of each compared to one another. The data for the HL shingles use a composition of 3% HL by weight of asphalt. The line 101 is a best-fit line through the data for the HL shingles of the invention, while the line 103 is the best-fit line through the data for the control.

The increased tear strength of the HL shingles of the present invention is an advantage over prior

shingles. The shingles of the present invention are more durable than prior shingles, and at a minimal added cost as HL is a low cost additive. The low cost is an advantage when compared to other asphalt shingles using polymeric materials as additives to improve strength.

While the invention has been shown in only one of its forms, it is not thus limited but is susceptible to various changes and modifications without departing from the spirit thereof.